Install sediment trapping devices

Sediment Basins and Rock Dams

Construction Site Storm Water Runoff Control

Description

Sediment basins and rock dams are two ways to capture sediment from storm water runoff before it leaves a construction site. Both structures allow a shallow pool to form in an excavated or natural depression where sediment from storm water runoff can settle. Basin dewatering is achieved either through a single riser and drainage hole leading to a suitable outlet on the downstream side of the embankment or through the gravel of the rock dam. In both cases, water is released at a substantially slower rate than would be possible without the control structure.

Sediment basins are used to trap sediments and temporarily detain runoff on larger construction sites

A sediment basin can be constructed by excavation or by erecting an earthen embankment across a low area or drainage swale. The basin can be either a temporary (up to 3 years) structure or a permanent storm water control measure. Sediment basins can be designed to drain completely during dry periods, or they can be constructed so that a shallow, permanent pool of water remains between storm events. However, depending on the size of the basin constructed, the basin may be considered a wet pond and subject to additional regulation.

Rock dams are similar in design to sediment basins with earthen embankments. These damming structures are constructed of rock and gravel and release water from the settling pool gradually through the spaces between the rock aggregate.

Applicability

Sediment basins are usually used for drainage areas of 5 to 100 acres. They can be temporary or permanent structures. Generally, sediment basins designed to be used for up to 3 years are described as temporary, while those designed for longer service are said to be permanent. Temporary sediment basins can be converted into permanent storm water runoff management ponds, but they must meet all regulatory requirements for wet ponds.

Sediment basins are applicable in drainage areas where it is anticipated that other erosion controls, such as sediment traps, will not be sufficient to prevent off-site transport of sediment. Choosing to construct a sediment basin with either an earthen embankment or a stone/rock dam will depend on the materials available, location of the basin, and desired capacity for storm water runoff and settling of sediments.

Rock dams are suitable where earthen embankments would be difficult to construct or where riprap is readily available. Rock structures are also desirable where the top of the dam structure is to be used as an overflow outlet. These riprap dams are best for drainage areas of less than 50 acres. Earthen damming structures are appropriate where failure of the dam will not result in substantial damage or loss of property or life. If properly constructed, sediment basins with earthen dams can handle storm water runoff from drainage basins as large as 100 acres.

Siting and Design Considerations

The potential sites for sediment basins should be investigated during the initial site evaluation. Basins should be constructed before any grading takes place within the drainage area. For structures that will be permanent, the design of the basin should be completed by a qualified professional engineer experienced in the design of dams.

Sediment basins with rock dams should be limited to a drainage area of 50 acres. Rock dam height should be limited to 8 feet with a minimum top width of 5 feet. Side slopes for rock dams should be no steeper than 2:1 on the basin side of the structure and 3:1 on the outlet side. The basin side of the rock dam should be covered with fine gravel from top to bottom for a minimum of 1 foot. This will slow the drainage rate from the pool that forms and allow time for sediments to settle. The detention time should be at least 8 hours.

Sediment basins with earthen embankments should be outfitted with a dewatering pipe and riser set just above the sediment removal cutoff level. The riser pipe should be located at the deepest point of the basin and extend no farther than 1 foot below the level of the earthen dam. A water-permeable cover should be placed over the primary dewatering riser pipe to prevent trash and debris from entering and clogging the spillway. To provide an additional path for water to enter the primary spillway, secondary dewatering holes can be drilled near the base of the riser pipe, provided the holes are protected with gravel to prevent sediment from entering the spillway piping.

To ensure adequate drainage, the following equation can be used to approximate the total area of dewatering holes for a particular basin (Smolen et al., 1988):

$$A_o = (A_s \text{ x } (2h) / (T \text{ x } C_d \text{ x } 20{,}428)$$

where

A_o = total surface area of dewatering holes, ft^2;

A_s = surface area of the basin, ft^2;

h = head of water above the hole, ft;

C_d = coefficient of contraction for an orifice, approximately 0.6; and

T = detention time or time needed to dewater the basin, hours.

In all cases, such structures should be designed by an appropriate professional based on local hydrologic, hydraulic, topographic, and sediment conditions.

Limitations

Neither a sediment basin with an earthen embankment nor a rock dam should be used in areas of continuously running water (live streams). The use of sediment basins is not intended for areas where failure of the earthen or rock dam will result in loss of life, or damage to homes or other buildings. In addition, sediment basins should not be used in areas where failure will prevent the use of public roads or utilities.

Maintenance Considerations

Routine inspection and maintenance of sediment basins is essential to their continued effectiveness. Basins should be inspected after each storm event to ensure proper drainage from the collection pool to determine the need for structural repairs. Erosion from the earthen embankment or stones moved from rock dams should be replaced immediately. Sediment basins must be located in an area that is easily accessible to maintenance crews for removal of accumulated sediment. Sediment should be removed from the basin when its storage capacity has reached approximately 50 percent. Trash and debris from around dewatering devices should be removed promptly after rainfall events.

Effectiveness

The effectiveness of a sediment basin depends primarily on the sediment particle size and the ratio of basin surface area to inflow rate (Smolen et al., 1988). Basins with a large surface area-to-volume ratio will be most effective. Studies have shown that the following equation relating surface area and peak inflow rate gives a trapping efficiency greater than 75 percent for most sediment in the Coastal Plain and Piedmont regions of the Southeastern United States (Barfield and Clar, in Smolen et al., 1988):

$$A = 0.01q$$

where A is the basin surface area in acres and q is the peak inflow rate in cubic feet per second.

USEPA (1993) estimates an average total suspended solids (TSS) removal rate for all sediment basins from 55 percent to 100 percent, with an average effectiveness of 70 percent.

Cost Considerations

If constructing a sediment basin with less than 50,000 ft^3 of storage space, the cost of installing the basin ranges from \$0.20 to \$1.30 per cubic foot of storage (about \$1,100 per acre of drainage). The average cost for basins with less than 50,000 ft^3 of storage is approximately \$0.60 per cubic foot of storage (USEPA, 1993). If constructing a sediment basin with more than 50,000 ft^3 of storage space, the cost range of installing the basin ranges from \$0.10 to \$0.40 per cubic foot of storage (about \$550 per acre of drainage). The average cost for basins with greater than 50,000 ft^3 of storage is approximately \$0.30 per cubic foot of storage (USEPA, 1993).

References

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

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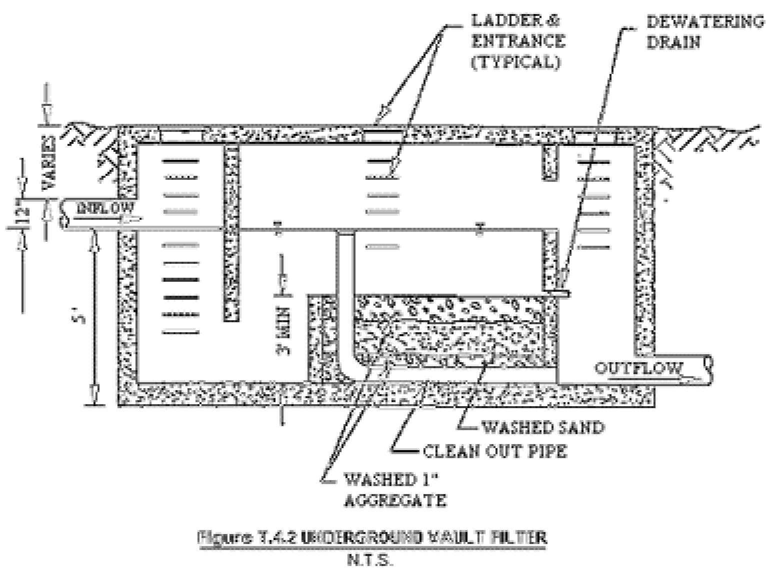
Sediment Filters and Sediment Chambers

Construction Site Storm Water Runoff Control

Description

Sediment filters are a class of sediment-trapping devices typically used to remove pollutants, primarily particulates, from storm water runoff. Generally speaking, sediment filters have four basic components: (1) inflow regulation, (2) pretreatment, (3) filter bed, and (4) outflow mechanism. Sediment chambers are merely one component of a sediment filter system.

Inflow regulation refers to the diversion of storm water runoff into the sediment-trapping device. After runoff enters the filter system, it enters a pretreatment sedimentation chamber. This chamber, used as a preliminary settling area for large debris and sediments, usually consists of nothing more than a wet detention basin. As water reaches a predetermined level, it flows over a weir into a filter bed of some filter medium. The filter medium is typically sand, but it can consist of sand, soil, gravel, peat, compost, or a combination of these materials. The purpose of the filter bed is to remove smaller sediments and other pollutants from the storm water as it percolates through the filter medium. Finally, treated flow exits the sediment filter system via an outflow mechanism to return to the storm water conveyance system.



Schematic representation of a sediment filter

Sediment filter systems can be confined or unconfined, on-line or off-line, and aboveground or belowground. Confined sediment filters are constructed with the filter medium contained in a structure, often a concrete vault. Unconfined sediment filters are constructed without encasing the filter medium in a confining structure. As one example, sand might be placed on the banks of a permanent wet pond detention system to create an unconfined filter. On-line systems are designed to retain storm water in its original stream channel or storm drain system. Off-line systems are designed to divert storm water.

Applicability

Sediment filters may be a good alternative for smaller construction sites where the use of a wet pond is being considered as a sediment-trapping device. Their applicability is wide ranging, and they can be used in urban areas with large amounts of highly impervious area. Because confined sand filters are man-made soil systems, they can be applied to most development sites and have few constraining factors (MWCOG, 1992). However, for all sediment filter systems, the drainage area to be serviced should be no more than 10 acres.

The type of filter system chosen depends on the amount of land available and the desired location within the site. Examples of sediment filter systems include the "Delaware" sand filter and the "Austin" sand filter. The Austin sand filter, so named because it first came into widespread use in Austin, Texas, is a surface filter system that can be used in areas with space restrictions. If space is at a premium, an underground filter may be the most appropriate choice. For effective storm water sediment control at the perimeter of a site, the Delaware sand filter might be a good choice. This configuration consists of two parallel, trench-like chambers installed at a site's perimeter. The first trench (sediment chamber) provides pretreatment sediment settling before the runoff spills into the second trench (filter medium).

Siting and Design Considerations

Available space is likely to be the most important siting and design consideration when choosing an appropriate sediment-filtering system. As mentioned previously, the decision as to which configuration is implemented on a particular site is dependent on the amount of space on a site. Another important consideration when deciding to install sediment-filtering systems is the amount of available head. Head refers to the vertical distance available between the inflow of the filter system and the outflow point. Because most filtering systems depend on gravity as the driving force to move water through the system, if a certain amount of head is not available, the system will not be effective and might cause more harm than good. For surface and underground sand filters, a minimum head of 5 feet is suggested (Claytor and Schueler, 1996). Perimeter sand filters such as the two-chambered Delaware sand filter should have a minimum available head of 2 to 3 feet (Claytor and Schueler, 1996).

The depth of filter media will vary depending on media type, but for sand filters it is recommended that the sand (0.04-inch diameter or smaller) be at least 18 inches deep, with a minimum of 4 to 6 inches of gravel for the bed of the filter. Throughout the life of a sediment filter system, there will be a need for frequent access to assess continued effectiveness and perform routine maintenance and emergency repairs. Because most maintenance of sediment filters requires manual rather than mechanical removal of sediments and debris, filter systems should be located to allow easy access.

Limitations

Sediment filters are usually limited to the removal of pollutants from storm water runoff. They must be used in combination with other storm water management practices to provide flood protection. Sediment filters should not be used on fill sites or near steep slopes (Livingston, 1997). In addition, sediment filters are likely to lose effectiveness in cold regions because of freezing conditions.

Maintenance Considerations

Maintenance of storm water sediment filters can be relatively high compared to other sediment-trapping devices. Routine maintenance includes raking the filter medium and removal of surface sediment and trash. These maintenance chores will likely need to be accomplished by manual labor rather than mechanical means. Depending on the medium used in the structure, the filter material may have to be changed or replaced up to several times a year. This will depend, among other things, on rainfall intensity and the expected sediment load.

Sediment filters of all media types should be inspected monthly and after each significant rainfall event to ensure proper filtration. Trash and debris removal should be removed during inspections. Sediment should be removed from filter inlets and sediment chambers when 75 percent of the storage volume has been filled. Because filter media have the potential for high loadings of metals and petroleum hydrocarbons, the filter medium should be periodically analyzed to prevent it from reaching levels that would classify it as a hazardous waste. This is especially true on sites where solvents or other potentially hazardous chemicals will be used. Spill prevention measures should be implemented as necessary. The top 3 to 4 inches of the filter medium should be replaced on an annual basis, or more frequently if drawdown does not occur within 36 hours of a storm event.

Effectiveness

Treatment effectiveness will depend on a number of factors, including treatment volume; whether the filter is on-line or off-line, confined or unconfined; and the type of land use in the contributing drainage area. MWCOG (1992) state that sand filter removal rates are "high" for sediment and trace metals and "moderate" for nutrients, BOD, and fecal coliform. Removal rates can be increased slightly by using a peat/sand mixture as the filter medium due to the adsorptive properties of peat (MWCOG, 1992). Estimated pollutant removal capabilities for various storm water sediment filter systems is shown in Table 1.

Table 1. Pollutant removal efficiencies for sand filters.

Source	Filter System	TSS[a] (%)	TP[a] (%)	TN[a] (%)	Other Pollutants
Claytor and Schueler, 1996	Surface Sand Filter	85	55	35	Bacteria: 40-80% Metals: 35-90%
	Perimeter Sand Filter	80	65	45	Hydrocarbons: 80%
Livingston, 1997	Sand Filter (general)	60–85	30–75	30–60	Metals: 30–80%

[a]TSS=total suspended solids; TP=total phosphorus; TN=total nitrogen

Cost Considerations

MWCOG (1992) estimates cost of construction for sand filters to be between $3.00 and $10.00 per cubic foot of runoff treated. Annual costs are estimated to be approximately 5 percent of construction costs.

References

Claytor, R., and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection, Silver Spring, MD.

Livingston. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems*. Watershed Management Institute, Ingleside, MD.

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Sediment Trap

Construction Site Storm Water Runoff Control

Description


Sediment traps are used to collect sediment-laden runoff from disturbed areas on construction sites

Sediment traps are small impoundments that allow sediment to settle out of runoff water. They are usually installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap (USEPA, 1993). Sediment traps are used to detain sediments in storm water runoff and trap the sediment to protect receiving streams, lakes, drainage systems, and the surrounding area.

Sediment traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff (USEPA, 1992).

Applicability

Sediment traps are generally temporary control measures to slow concentrated runoff velocity and catch sediment, and they can be used with other temporary storm water control measures. They are commonly used at the outlets of storm water diversion structures, channels, slope drains, construction site entrance wash racks, or any other runoff conveyance that discharges waters containing erosion sediment and debris. Sediment traps can also be used as part of a storm water drop intake protection system when the inlet is located below a disturbed area and will receive runoff with large amounts of sediment.

Siting and Design Considerations

Sediment traps can simplify the storm water control plan design process by trapping sediment at specific spots at a construction site (USEPA, 1992). Therefore, they should be installed as early in the construction process as possible. Natural drainage patterns should be noted, and sites where runoff from potential erosion can be directed into the traps should be selected. Sediment traps should not be located in areas where their failure due to storm water runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways should be designed to accommodate these potential overflows.

A sediment trap should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the trap and decrease the likelihood of backup during and after periods of high runoff intensity. Although site conditions will dictate specific design criteria, the approximate storage capacity of each trap should be at least 1,800 ft^3 per acre of total drainage area

(Smolen et al., 1988). The volume of a natural sedimentation trap can be approximated by the following equation (Smolen et al., 1988):

$$\text{Volume (ft}^3\text{)} = 0.4 \text{ x surface area (ft}^2\text{) x maximum pool depth (ft)}$$

Care should be taken in the siting and design phase to situate sediment traps for easy access by maintenance crews. This will allow for proper inspection and maintenance on a periodic basis. When excavating an area for sediment trap implementation, side slopes should not be steeper than 2:1 and embankment height should not exceed 5 feet from the original ground surface. All embankments should be machine compacted to ensure stability. To reduce flow rate from the trap, the outlet should be lined with well-graded stone.

The spillway weir for each temporary sediment trap should be at least 4 feet long for a 1-acre drainage area and increase by 2 feet for each additional drainage acre added, up to a maximum drainage area of 5 acres.

Limitations

Sediment traps should not be used for drainage areas greater than 5 acres (USEPA, 1993). The effective life span of these temporary structures is usually limited to 24 months (Smolen et al., 1988). Although sediment traps allow for settling of eroded soils, because of their short detention periods for storm water they typically do not remove fine particles such as silts and clays.

Maintenance Considerations

The primary maintenance consideration for temporary sediment traps is the removal of accumulated sediment from the basin. This must be done periodically to ensure the continued effectiveness of the sediment trap. Sediments should be removed when the basin reaches approximately 50 percent sediment capacity. A sediment trap should be inspected after each rainfall event to ensure that the trap is draining properly. Inspectors should also check the structure for damage from erosion. The depth of the spillway should be checked and maintained at a minimum of 1.5 feet below the low point of the trap embankment.

Effectiveness

Sediment trapping efficiency is a function of surface area, inflow rate, and the sediment properties (Smolen et al., 1988). Those traps that provide pools with large length-to-width ratios have a greater chance of success. Sediment traps have a useful life of approximately 18 to 24 months (USEPA, 1993), although ultimately effectiveness depends on the amount and intensity of rainfall and erosion, and proper maintenance. USEPA (1993) estimates an average total suspended solids removal rate of 60 percent. An efficiency rate of 75 percent can be obtained for most Coastal Plain and Piedmont soils by using the following equation (Barfield and Clar, in Smolen et al., 1988):

$$\text{Surface area at design flow (acres)} = (0.01) \text{ peak inflow rate (cfs)}$$

Cost Considerations

The cost of installing temporary sediment traps ranges from \$0.20 to \$2.00 per cubic foot of storage (about \$1,100 per acre of drainage). The average cost is approximately \$0.60 per cubic foot of storage (USEPA, 1993).

References

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

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Inlet protection

Storm Drain Inlet Protection

Construction Site Storm Water Control

Description

Storm drain inlet protection measures are controls that help prevent soil and debris from site erosion from entering storm drain drop inlets. Typically, these measures are temporary controls that are implemented prior to large-scale disturbance of the surrounding site. These controls are advantageous because their implementation allows storm drains to be used during even the early stages of construction activities. The early use of storm drains during project development significantly reduces the occurrence of future erosion problems (Smolen et al., 1988).

Coarse gravel and cinder blocks are often used to keep sediment and other pollutants out of storm drains

Three temporary control measures to protect storm drain drop inlets are

- Excavation around the perimeter of the drop inlet
- Fabric barriers around inlet entrances
- Block and gravel protection.

Excavation around a storm drain inlet creates a settling pool to remove sediments. Weep holes protected by gravel are used to drain the shallow pool of water that accumulates around the inlet. A fabric barrier made of porous material erected around an inlet can create an effective shield to erosion sediment while allowing water flow into the storm drain. This type of barrier can slow runoff velocity while catching soil and other debris at the drain inlet. Block and gravel inlet protection uses standard concrete blocks and gravel to form a barrier to sediments while permitting water runoff through select blocks laid sideways. In addition to the materials listed above, limited temporary storm water drop inlet protection can also be achieved with the use of straw bales or sandbags to create barriers to sediment. For permanent storm drain drop inlet protection after the surrounding area has been stabilized, sod can be installed as a barrier to slow storm water entry to storm drain inlets and capture erosion sediments. This final inlet protection measure can be used as an aesthetically pleasing way to slow storm water velocity near drop inlet entrances and to remove sediments and other pollutants from runoff.

Applicability

All temporary controls should have a drainage area no greater than 1 acre per inlet. It is also important for temporary controls to be constructed prior to disturbance of the surrounding landscape. Excavated drop inlet protection and block and gravel inlet protection are applicable to areas of high flow where overflow is anticipated into the storm drain. Fabric barriers are recommended for smaller, relatively flat drainage areas (slopes less than 5 percent leading to the storm drain). Temporary drop inlet control measures are often used in combination with each other and other storm water control techniques.

Siting and Design Considerations

With the exception of sod drop inlet protection, these controls should be installed before any soil disturbance in the drainage area. Excavation around drop inlets should be dug a minimum of 1 foot deep (2 feet maximum) with a minimum excavated volume of 35 yd^3 per acre disturbed. Side slopes leading to the inlet should be no steeper than 2:1. The shape of the excavated area should be designed such that the dimensions fit the area from which storm water is anticipated to drain. For example, the longest side of an excavated area should be along the side of the inlet expected to drain the largest area.

Fabric inlet protection should be staked close to the inlet to prevent overflow on unprotected soils. Stakes should be used with a minimum length of 3 feet, spaced no more than 3 feet apart. A frame should be constructed for fabric support during overflow periods and should be buried at least 1 foot below the soil surface and rise to a height no greater than 1.5 feet above ground. The top of the frame and fabric should be below the down-slope ground elevation to prevent runoff bypassing the inlet.

Block and gravel inlet barrier height should be 1 foot minimum (2 feet maximum), and mortar should not be used. The bottom row of blocks should be laid at least 2 inches below the soil surface flush against the drain for stability. One block in the bottom row should be placed on each side of the inlet on its side to allow drainage. Wire mesh (1/2 inch) should be placed over all block openings to prevent gravel from entering the inlet, and gravel (3/4 to 1/2 inch in diameter) should be placed outside the block structure at a slope no greater than 2:1.

Sod inlet protection should not be considered until the entire surrounding drainage area is stabilized. The sod should be laid so that it extends at least 4 feet from the inlet in each direction to form a continuous mat the around inlet, laying sod strips perpendicular to the direction of flows. The sod strips should be staggered such that strip ends are not aligned, and the slope of the sodded area should not be steeper than 4:1 approaching the drop inlet.

Limitations

Storm water drop inlet protection measures should not be used as stand-alone sediment control measures. To increase inlet protection effectiveness, these practices should be used in combination with other measures, such as small impoundments or sediment traps (USEPA, 1992). Temporary storm drain inlet protection is not intended for use in drainage areas larger than 1 acre. Generally, storm water inlet protection measures are practical for relatively low-sediment, low-volume flows. Frequent maintenance of storm drain control structures is necessary to prevent clogging. If sediment and other debris clog the water intake, drop intake control measures can actually cause erosion in unprotected areas.

Maintenance Considerations

All temporary control measures must be checked after each storm event. To maintain the sediment capacity of the shallow settling pools created from these techniques, accumulated sediment should be removed from the area around the drop inlet (excavated area, around fabric barrier, or around block structure) when the sediment capacity is reduced by approximately 50 percent. Additional debris should be removed from the shallow pools on a periodic basis. Weep holes in excavated areas around inlets can become clogged and prevent water from draining out of shallow pools that form. Should this happen, unclogging the water intake may be difficult and costly.

Effectiveness

Excavated drop inlet protection may be used to improve the effectiveness and reliability of other sediment traps and barriers, such as fabric or block and gravel inlet protection. However, as a whole, the effectiveness of inlet protection is low for erosion and sediment control, long-term pollutant removal, and low for habitat and stream protection.

Cost Considerations

The cost of implementing storm drain drop inlet protection measures will vary depending on the control measure chosen. Generally, initial installation costs range from $50 to $150 per inlet, with an average cost of $100 (USEPA, 1993). Maintenance costs can be high (up to 100 percent of the initial construction cost annually) due to frequent inspection and repair needs. The Southeastern Wisconsin Regional Planning Commission has estimated that the cost of installation of inlet protection devices ranges from $106 to $154 per inlet (SEWRPC, 1991).

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